

黄精族 4 属 6 种的核型报道

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REPORT ON KARYOTYPES OF 6 SPECIES IN 4 GENERA OF POLYGONATEAE FROM CHINA

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Summary Cytotaxonomically investigated in this work were 6 species in 4 genera of Polygonateae (sensu Krause, 1930). Each species was karyotypically analysed using 5 somatic metaphase cells with well-spread chromosomes. The chromosome classification follows Levan et al. (1964) and the karyotype classification is according to Stebbins (1971). The materials used are listed in the Appendix and the vouchers are deposited in PE. The chromosome numbers and karyotypes of *Disporum megalanthum* and *Disporopsis aspera* are reported here for the first time, and those of Chinese *Maianthemum bifolium* are also reported for the first time. The results are shown as follows.

(1) **Disporum** Salisb. **D. megalanthum** Wang et Tang from the Wolong Nature Reserve, Sichuan, is found to have a karyotype $2n=16=2m(1SAT)+6sm(1SAT)+8st(3SAT)$ (Plate I, A). The parameters of chromosomes are listed in Table 1 and the idiogram is shown in Fig. 1, A. The chromosomes range in length from 8.5 to 29.3 μm , with the ratio of the longest to the shortest 3.45. The karyotype belongs to Stebbins' (1971) 3B. In a somatic chromosome complement the 2nd, 4th, 6th and 7th pairs each have one chromosome carrying a satellite, showing heterozygosity.

Another material from the Qinling Range, Shaanxi, is shown to have $2n=16=2m(1SAT)+8sm(3SAT)+6st$ (Plate 1, B). The parameters of chromosomes are listed in Table 1 and the idiogram is presented in Fig. 1, B. The chromosomes range in length from 6.3 to 22.6 μm , with the ratio of the longest to the shortest 3.61, and thus the karyotype belongs to 3B. The karyotype shows clear heterozygosity (Fig. 1, B). The two chromosomes of the first

pair have arm ratios 2.38 and 1.82 respectively, but they are equal in length, 22.6 μm . It seems to us that a pericentric inversion has taken place in one of the two chromosomes. Moreover, the 3rd and 4th pairs each have one chromosome carrying a satellite attached to the long arm.

These two materials are of the basically same karyotype, the major difference between them being that the 3rd pair in the former consists of two st chromosomes with the arm ratio 3.15, while the corresponding pair in the other is of two m chromosomes with an arm ratio 1.67.

Seven East-Asian species of the genus *Disporum* are reported to have $2n=14$, 16 and 18 (or $16+2B?$), but $2n=16$ is common to all the species, and therefore the basic number of the group is $x=8$. For the North American group of the genus, however, 3 species (*D. hookeri*, *D. lanuginosum*, *D. oreganum*) are of $2n=18$, *D. smithii* is of $2n=16$, and *D. maculatum* $2n=12$. Chromosome numbers are more variable in the North American group, but $x=9$ seems to be a dominant basic number. Even more striking difference in karyotype between the two groups exists in size of chromosomes, 2.0—4.9 μm for the North American group, while 4.0—16.0 μm for the East-Asian counterpart (Therman, 1956) (Our result shows 6.3—22.6 μm and 8.5—29.3 μm for the two materials). This remarkable contrast in karyotype is clearly correlated with the differentiation in gross morphology. The East-Asian species have calcarate tepals but no reticulate veins of leaves, whereas the North American ones have reticulate veins but spurless tepals. The evidence from karyotype and morphology seems to justify the restoration of the genus *Prosartes* for the North American species (Conover, 1983, cf. Dahlgren et al. 1985).

(2) **Disporopsis** Hance *D. pernyi* (Hua) Diels from Mapien, Sichuan, is of $2n=40=23m(2SAT)+13sm(2SAT)+2st+2t(2SAT)$ (Plate 1, C). The parameters of chromosomes are listed in Table 2, and the idiogram is shown in Fig. 2, A. The chromosomes range in length 5.2—16.2 μm , with the ratio of the longest to the shortest 3.11, and thus the karyotype belongs to 2B.

D. aspera (Hua) Engl. ex Krause also from Mapien, Sichuan, is found to have $2n=40=30m+8sm(2SAT)+2t(2SAT)$ (Plate 1, D). The parameters of chromosomes are listed in Table 2, and the idiogram is shown in Fig. 2, B. The chromosomes range in length 5.2—14.7 μm , with the ratio of the longest to the shortest 2.84. Therefore, the karyotype belongs to 2B. Another material from the same locality but different population was also examined and found to have $2n=40=30m+6sm+2st(2SAT)$ (Fig. 2, C).

D. arisanensis (= *D. pernyi*) from Taiwan is reported to have $2n=40=26m+12sm+2st$ (Chang and Hsu, 1974), *D. fusco-picta* from the Philippines $2n=40=22m+16sm+2st(2SAT)$ (Kumar and Brandham, 1974), and *D. longifolia* from Thailand $2n=40$ (Larsen, 1963). Thus, the species in the genus, except the newly described *D. jingfushanensis* Z. Y. Liu (1987) with no chromosome data, are all of $2n=40$, and the basic number of the genus is $x=20$. From the karyotype formulae, asymmetry of the karyotypes increases from *D. aspera* to *D. fusco-picta* through *D. pernyi*, which may be correlated with the increasing specialization of gross morphology.

(3) **Maianthemum** Web. *M. bifolium* (L.) F. W. Schmidt from the Qinling Range, Shaanxi, is found to have $2n=36=20m+10sm+4st+2t(2SAT)$ (Plate 1, H). The parameters of the chromosomes are listed in Table 3, and the idiogram

is shown in Fig. 3, D. The chromosome lengths range $2.4-8.2\mu\text{m}$, with the ratio of the longest to the shortest 3.43. The karyotype thus belongs to 2B, and is slightly bimodal: the first 10 pairs and the pair of sat chromosomes are larger than the rest 7 pairs, the ratio of the shortest in the former group to the longest in the latter group being 1.24.

(4) **Polygonatum** Mill. **P. humile** Fisch. ex Maxim. from Chicheng County, Hebei, is shown to have a karyotype $2n=20=10m(2\text{SAT})+6sm(2\text{SAT})+4st$ (Plate 1, G). The parameters of chromosomes are listed in Table 4, and the haploid idiogram is shown in Fig. 3, C. The chromosome lengths range from 3.0 to $10.0\mu\text{m}$ with the ratio of the longest to the shortest 3.3. The karyotype therefore belongs to 2B.

P. odoratum (Mill.) Druce Two materials in this species were examined. One from Chicheng County, Hebei, has $2n=20=10m+10sm(3\text{SAT})$ (Plate 1, E). The parameters of chromosomes are presented in Table 4 and the somatic idiogram in Fig. 3, A. The chromosomes range in length $3.1-8.8\mu\text{m}$, with the ratio of the longest to the shortest 2.8. The karyotype is thus of 2B. The other from the Qinling Range, Shaanxi, is found to have $2n=20=12m(4\text{SAT})+8sm(2\text{SAT})$ (Plate 1, F). The parameters of chromosomes are listed in Table 4, and the haploid idiogram is shown in Fig. 3, B. The chromosomes range in length $4.2-10.9\mu\text{m}$, with the ratio of the longest to the shortest 2.6. The karyotype is also of 2B.

P. odoratum is widely distributed in Eurasian temperate region and its cytological reports are frequently seen. All the materials outside of China, from Portugal to Japan, are reported to have $2n=20$, except one material from east Sayan in SE Siberia, which is reported to have $2n=30$ (Krogulevich, 1978). In China, however, three chromosome numbers have so far been reported under the name *P. odoratum*, $2n=20$ from the Changbai Mountains, Jilin Province (Fang, 1989), Qinlong County, Hebei Province (Wang et al. 1987), the Jinfo Mountains, Sichuan Province (in cultivation), besides the two materials used in this work; $2n=22$ from Mt. Jinshan in Beijing (Li, 1980), Wuhan in Hubei Province, Yixin in Jiangsu Province and Mt. Emei in Sichuan Province (Fang, 1989); $2n=18$ from Yixin in Jiangsu Province and the Dabien Mountains in Anhui Province (Fang, 1989). It is, therefore, rather evident that the species under discussion is variable in chromosome number only in the southern part of its distribution area. Karyotypical morphology is also variable in this species. The $2n=20$ group is found to have following karyotypes: $12m(4\text{SAT})+8sm$ (in Austria, Hong et al. unpubl.), $14m+6sm$ (Jilin): $12m+8sm$ (Qinlong, Hebei): $10m+10sm(3\text{SAT})$ (Chicheng, Hebei): $12m(4\text{SAT})+8sm(2\text{SAT})$ (Shaanxi) and $10m+6sm+4st$ (Mt. Jinfo, Sichuan). For the $2n=18$ group, $10m+8sm$ (Anhui) and $8m+10sm$ (Jiangsu) have been found. In the $2n=22$ group these karyotype formulae so far reported are all $10m+8sm+4st$. Comparing the karyotypes in the three groups we find that 4st chromosomes are always present in the $2n=22$ group, while in the other two groups, except the karyotype $10m+6sm+4st$ found from the Jinfo Mountains in Sichuan, all the karyotypes consist of m and sm chromosomes.

Based on the correlation between karyotypical data and cryptic morphological differences Wang et al. (1988) consider *Polygonatum odoratum* as a complex, which consists of three species: *Polygonatum odoratum* (s. str. $2n=20$), *P. macropodium* Turcz. ($2n=22$) and *P. simizui* Kitag. ($2n=18$). But in this complex biosystematic problems, such as relationship bet-

ween chromosome number and chromosome structure, evolutionary relationship of the different chromosome numbers, relationship between means of reproduction (extent of vegetative propagation) and karyotype variation are still unresolved and deserve further studies.

摘要 本文报道四川、陕西、河北的百合科黄精族 4 属 6 种的染色体数目和核型。 *Disporum megalanthum* $2n = 16 = 2m(1SAT) + 6sm(1SAT) + 8st(3SAT)$ and $2n = 16 = 2m(1SAT) + 8sm(3SAT) + 6st$, 3B 型; *Disporopsis pernyi* $2n = 40 = 23m(2SAT) + 13sm(2SAT) + 2st + 2t(2SAT)$, 2B 型; *Disporopsis aspera* $2n = 40 = 30m + 8sm(2SAT) + 2t(2SAT)$, 2B 型; *Maianthemum bifolium* $2n = 36 = 20m = 10sm + 4st + 2t(2SAT)$, 2B 型; *Polygonatum odoratum* $2n = 20 = 10m + 10sm(3SAT)$, 2B 和 $2n = 20 = 12m(4SAT) + 8sm(2SAT)$, 2B 型; *Polygonatum humile* $2n = 20 = 10m(2SAT) + 6sm(2SAT) + 4t$, 2B 型。从染色体角度, 并联系形态特征, 对 *Disporum* 属中分别见于东亚和北美的两个类群的关系作了讨论。也讨论了 *Disporopsis* 种间在核型不对称趋势与形态特化之间可能的关系。本文还指出 *Polygonatum odoratum* 和 *Polygonatum humile* 种内核型的多变性。

关键词 百合科; 黄精族; 万寿竹属; 竹根七属; 舞鹤草属; 黄精属; 核型; 细胞分类学

黄精族, 按 Krause (1930) 的系统, 包括 8 个属, 我国有 7 个。这一概念在 Hutchinson (1973) 的系统中维持不变, 但在 Dahlgren 等人 (Dahlgren et al. 1985) 的系统中, 该族作为 Convallariaceae (Asparagales) 中的一个族, 而且范围大大缩小了, 他们把 *Clintonia*, *Disporum* 和 *Streptopus* 移置于 Uvulariaceae (Liliales) 中的 Uvulariaceae 族中。还认为分布于澳大利亚的 *Drymophila* 也不应该留在黄精族中, 而应是 Uvulariaceae 或 Luzuriagaceae (Asparagales) 中的成员。对 *Disporopsis* 的地位, 他们没有提及。这样, 按后一系统, 黄精族最多只包括 4 个属, 即 *Polygonatum*, *Maianthemum*, *Smilacina* 和 *Disporopsis*。由此可见, Dahlgren 等人的系统不仅大大改变了该族的概念, 而且对成员间的亲缘关系亦有迥然不同的见解, 被置于两个不同的目中。本文暂时采用 Krause 的概念。

材 料 和 方 法

实验材料取自四川、陕西和河北。直接在野外或移栽于温室后取生长旺盛的根尖, 用 0.05% 的秋水仙碱和 0.002mol/L 8-羟基喹啉等量混合液予处理 2—4 小时 (竹根七两个种的材料用 0.025% 的秋水仙碱预处理 5 小时), 其它步骤与第一篇 (洪德元和朱相云, 1987) 相同。

材料来源见附录 1, 凭证标本全部存中国科学院植物研究所标本馆 (PE) 中。

观察结果与讨论

(一) 万寿竹属 *Disporum* Salisb.

1. 大花万寿竹 *Disporum megalanthum* Wang et Tang 包括两号材料, 一号来自四川卧龙自然保护区, 其体细胞染色体数目为 $2n = 16$ (图版 1: A), 体细胞核型模式图见图 1: A。核型公式为 $2n = 16 = 2m(1SAT) + 6sm(1SAT) + 8st(3SAT)$, 染色体

参数见表 1, 染色体大小为 $8.5-29.3\mu\text{m}$, 最长与最短染色体的比值为 3.45, 核型属 Stebbins 的 3B 型。染色体组分中第 2, 3, 4, 6 和 7 对各有一条的长臂末端带有随体, 表现杂合性。

另一号材料来自陕西太白山, 染色体数目为 $2n=16$ (图版 1: B), 体细胞核型模式图见图 1: B, 核型公式为 $2n=16=2m(1\text{SAT})+8sm(3\text{SAT})+6st$, 染色体各参数见表 1, 染色体大小为 $6.3-22.6\mu\text{m}$, 最长与最短染色体的比值为 3.61, 核型为 3B。该核型呈现明显的杂合性(图 1: B), 第一对染色体的臂比分别为 2.38 和 1.82, 但长度一致, 均为 $22.6\mu\text{m}$, 看来其中一条发生了臂间倒位, 使臂比增大。另外第 3、4 两对染色体各有一条长臂的末端带有随体, 表现出随体有无的杂合性。这是对该种染色体数目和核型的首次报道。

对比两号材料的核型模式图, 可以看出它们相当一致。除随体数目和位置的不同以及太白山材料的第一对染色体表现出杂合性外, 主要差异在于四川卧龙的材料第 3 对为具近末端着丝粒染色体, 臂比为 3.15, 而另一材料第 3 对则为具中部着丝粒染色体, 臂比为 1.67。结合 Kayano (1960) 的报道, 我们推测四川卧龙植株的第 3 对染色体经历了臂间倒位。

对于该属的染色体数目和核型, 已有大量报道。分布于东亚的 *D. bodinieri* 具 $n=8$ 或 $n=8+1B$ (洪德元等, 未发表); *D. cantoniense* 具有 $n=8$ (汤彦承等, 1984); $2n=16$ (Kurosawa 1966); $2n=14, 16$ (Kurosawa 1971); $2n=14$ (Mehra et al. 1976); *D. smilacinum* $2n=16$ (Darlington & Wylie 1955); *D. viridescens* $2n=16$ (Therman 1956); *D. pullum* $2n=16$ (Hasegawa 1932; Darlington & Wylie 1955); *D. kawakamii* $2n=16$ (Chang et al. 1974); *D. shimdai* $2n=14, 16$ (Chang et al. 1974); *D. calcaratum* $2n=18 (16+2B?)$ (Larsen, 1963)。可见, 至今报道的东亚 7 个种虽然染色体数目有变异, 但都有 $2n=16$ 。因此该类群的染色体基数为 $x=8$ 。根据 Therman (1956), 东亚各种染色体长度范围为 $4.0-16.0\mu\text{m}$ (我们的结果显示 $6.3-29.3\mu\text{m}$)。分布于北美的 *D. maculatum*, $2n=12$ (Darlington & Wylie 1955); *D. smithii* $2n=16$ (Darlington & Wylie 1955; Therman 1956); *D. hookeri* $2n=18$ 和 *D. lanuginosum* $2n=18$ (Darlington & Wylie 1955; *D. oreganum* $2n=18$ (Therman 1956)。显然, 北美的类群以 $x=9$ 为主。按照 Therman (1956) 的报道, 北美类群的染色体长度为 $2.0-4.9\mu\text{m}$ 。由此可见, 东亚和北美的类群在核型方面的分化已经十分明显。不仅如此, 形态上它们也彼此不同, 东亚的类群的花被片基部常有距, 叶片无网状脉, 而北美的类群则无距, 叶具网状脉。因而近来倾向于为北美类群恢复独立的属 (*Prosartes* D. Don) 的地位 (Conover 1983, cf. Dahlgren et al. 1985)

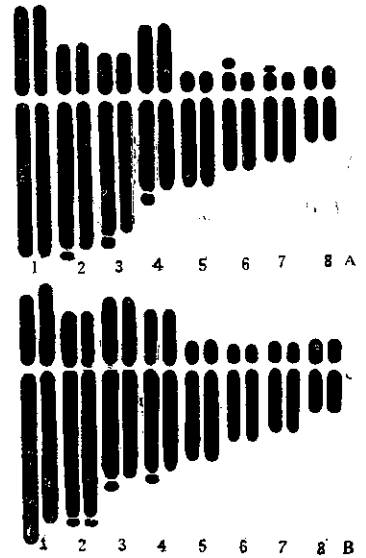


图 1 大花万寿竹两号材料的体细胞核型模式图

Fig. 1 Somatic idiograms of two materials in *Disporum megalanthum*:

A. PB85016; B. PB85060.

表 1 大花万寿竹两号材料的染色体参数

Table The parameters of chromosomes of two materials in *Disporum megalanthum*

	chr. No	relative length (l. + s. = total)	arm ratio	chr. type
PB85016	1	13.7+7.9=21.6	1.72	sm
	2	13.2+4.5+0.6=18.3 13.2+4.5=17.7	2.9	sm
	3	11.7+3.7+1.1=16.5 11.7+3.7=15.4	3.15	st
	4	8.1+6.2+0.8=15.1 8.1+6.2=14.3	1.31	m
	5	7.7+1.8=9.5	4.36	st
	6	6.4+1.6+0.8=8.8 6.4+1.6=8.0	3.91	st
	7	5.6+1.2+0.4=7.2 5.6+1.2=6.8	3.62	st
	8	4.0+2.2=6.2	1.83	sm
PB85060	1	15.3+6.3=21.6 13.4+7.4=20.8	2.38 1.82	sm
	2	13.1+4.9+0.5=18.5	2.67	sm
	3	9.7+5.8+0.7=16.2 9.7+5.8=15.5	1.67	m
	4	9.1+4.8+0.6=14.5 9.1+4.8=13.9	1.83	sm
	5	8.3+1.9=10.2	4.25	st
	6	6.3+1.5=7.8	4.34	st
	7	5.9+1.5=7.4	3.88	st
	8	3.7+2.2=5.9	1.7	sm

(二) 竹根七属 *Disporopsis* Hance1. 深裂竹根七 *Disporopsis pernyi* (Hua) Diels

材料取自四川马边,其染色体数目为 $2n = 40$ (图版 1: C),核型模式图见图 2:A,核型公式为 $2n = 40 = 23m(2SAT) + 13sm(2SAT) + 2st + 2t(2SAT)$,染色体参数见表 2,染色体长度为 5.2—16.2 μm ,最长与最短染色体的比值为 3.11,核型为 2B 型。第 20 对染色体一条相对长为 2.90,臂比为 2.33,另一条相对长为 3.33,臂比为 1.25,两条同源染色体长度基本一致,但臂比相差悬殊,看来是臂间倒位造成的杂合性。这是该种大陆材料染色体和核型的第一次报道。

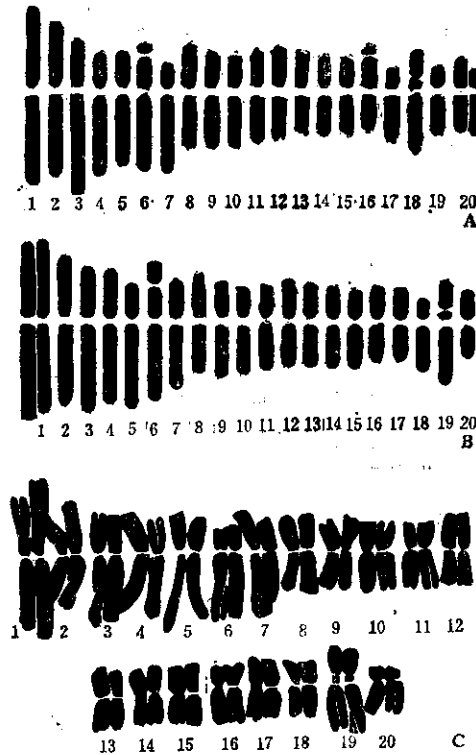


图2 竹根七属两个种的核型模式图和核型图

Fig. 2. Idiograms and karyogram of two species in *Disporopsis*. A. *D. pernyi* (PB84044); B. *D. aspera* (PB84047); C. *D. aspera* (PB84020).

2. 散斑竹根七 *Disporopsis aspera* (Hua) Engl. ex Krause

材料取自四川马边, 染色体数目亦为 $2n = 40$ (图版 1: D), 核型模式图见图 2: B, 核型公式为 $2n = 40 = 30m + 8sm(2SAT) + 2t(2SAT)$, 染色体参数见表 2, 染色体大小为 $5.2-14.7\mu m$, 最长与最短染色体的比值为 2.84, 核型 2B。本种的另一号材料同样取自四川马边, 其核型图见图 2: C, 核型公式为 $2n = 40 = 30m + 6sm + 2st + 2t(2SAT)$, 染色体长度为 $4.9-16.6\mu m$, 最长与最短染色体的比值为 3.39, 核型属 2B。与前一个居群的区别在于这里有两条 *st* 染色体代替了 *sm* 染色体, 而仅有两条随体系于 *t* 染色体上。看来随体即使在同一地区也是不一致的。这是该种染色体数目和核型的首次报道。

Sato (1942) 报道东京大学 Koisikawa 植物园的 *Disporopsis arisanensis* (= *D. pernyi*) 为 $2n = 40$ 。Chang et al. (1974) 报道来自台湾的 *Disporopsis arisanensis* (= *D. pernyi*) 亦为 $2n = 40$, 其核型公式为 $2n = 40 = 26m + 12sm + 2st$ 。Kumar & Brandham (1980) 报道菲律宾吕宋岛的 *Disporopsis fusco-picta* 为 $2n = 40$, 其核型公式为 $2n = 40 = 22m + 16sm + 2st(2SAT)$, 核型属 2B 型, 第 4 对染色体表现出杂合性。Larsen (1963) 报道泰国的 *Disporopsis longifolia* 亦为 $2n = 40$ 。这样,

表2 竹根七属两个种的染色体参数

Table 2 The parameters of chromosomes in two species of *Disporopsis* Hance

Disporopsis pernyi (Hua) Diels				Disporopsis aspera (Hua) Engl. ex Krause			
chr. No.	relative length (l. + s. = total)	arm ratio	chr. type	chr. No.	relative length (l. + s. = total)	arm ratio	chr. type
1	4.8+4.3=9.1	1.12	m	1	4.9+3.9=8.8 4.4+4.1=8.5	1.26 1.08	m m
2	4.4+3.4=7.8	1.29	m	2	4.1+3.2=7.3	1.28	m
3	5.2+2.6=7.8	2.01	sm	3	4.6+2.7=7.3	1.73	sm
4	4.3+1.8=6.1	2.36	sm	4	4.1+2.5=6.6	1.64	m
5	3.8+1.9=5.7	1.95	sm	5	4.4+1.7=6.1	2.62	sm
6	4.0+1.6+0.5=5.6	2.53	sm	6	3.9+1.6+0.9=6.4	2.40	sm
7	4.1+1.2=5.3	3.36	st	7	3.3+2.2=5.5	1.53	m
8	2.7+2.3=5.0	1.18	m	8	2.4+2.3=4.7	1.07	m
9	2.9+1.9=4.8	1.48	m	9	2.7+1.9=4.6	1.43	m
10	2.8+1.8=4.6	1.59	m	10	2.6+1.8=4.4	1.43	m
11	2.5+1.8=4.3	1.41	m	11	2.3+1.8=4.1	1.31	m
12	2.2+2.0=4.2	1.10	m	12	2.1+2.0=4.1	1.06	m
13	1.9+1.9=3.8	1.05	m	13	2.1+1.8=3.9	1.16	m
14	2.2+1.6=3.8	1.38	m	14	2.2+1.7=3.9	1.29	m
15	2.0+1.5=3.5	1.29	m	15	2.2+1.5=3.7	1.49	m
16	1.8+1.6+0.4=3.8	1.10	m	16	1.9+1.8=3.7	1.05	m
17	2.4+0.9=3.3	2.6	sm	17	1.9+1.7=3.6	1.14	m
18	3.0+0.4+1.4=4.8	8.25	t	18	2.4+1.1=3.5	2.29	sm
19	2.1+1.1=3.3	1.93	sm	19	3.0+0.4+1.5=4.9	7.21	t
20	2.0+0.9=2.9 1.9+1.5=3.4	2.33 1.25	sm m	20	1.6+1.5=3.1	1.10	m

Disporopsis 至今记载 5 种,除 *D. jingfushanensis* Z. Y. Liu (1987) 这一新种外,均有较广阔的分布区,且都有染色体资料,均为 $2n = 40$,几乎可以肯定,该属的基数为 $x = 20$,是一个古多倍体属。该属除具有副花冠这一特化性状外,和 *Polygonatum* 非常相似,因而很可能由 *Polygonatum* 中 $2n = 20$ 的某一类群经由多倍化过程演化而来。

Disporopsis aspera 有 30 条 m 染色体, *D. pernyi* 有 23—26 条 m 染色体, *D. fusco-picta* 有 22 条 m 染色体,核型不对称性依次增强。这一趋势可能与形态上的特化有关。*D. pernyi* 的副花冠裂片与花被裂片对生, *D. fusco-picta* 的副花冠裂片虽与花被裂片互生,但其根状茎念珠状,也是特化性状。

(三) 舞鹤草属 *Maianthemum* Web.

舞鹤草 *Maianthemum bifolium* (L.) F. W. Schmidt. 材料取自陕西太白山,染色

体数目为 $2n = 36$ (图版 1: H), 单倍核型模式图见图 3: D。核型公式为 $2n = 36 = 20m + 10sm + 4st + 2t(2SAT)$ 。染色体参数见表 3, 染色体大小为 $2.4-8.2\mu m$, 最长与最短染色体的比值为 3.43, 核型为 2B。该种核型呈现不明显的两型性: 前 10 对和随体染色体为大型, 其余 7 对为小型, 大型染色体中最小的与小型染色体中最大的之比值为 1.24。这是首次报道中国材料的染色体数目和核型。

该种在北温带广布, 欧亚大陆从西至东以及北美均有分布。就至今大量的染色体报道来看, 欧洲和北美的材料均为 $2n = 36$ (Fedorov, 1969; Moore, 1973; Goldblatt, 1981, 1984; Hong et al. 未发表)。但在日本, 有 $n = 17$, $2n = 36, 54, 64-70$ 等报道 (Fedorov, 1969; Moore, 1973); 在苏联东西伯利亚和远东地区发现有 $2n = 36, 54, 64-70$ 以及 88 (Goldblatt, 1981, 1984)。可见在亚洲东部, 染色体数目有变化。分析这个种的染色体数目, 可以看出, $2n = 36$ 是最常见的, $2n = 54$ 次之。另外两个种 (*M. canadense* 和 *M. dilatata*) 也都有 $2n = 36$, 或兼有 $2n = 54$ 。由此可见, $2n = 36$ 虽然从现有资料分析是一个二倍体, 但由于有 $2n = 54$ 的存在, 我们可以推测, 它实际上是一个以 $x = 9$ 为基数的古四倍体; $2n = 54$ 实际上是六倍体。真正的二倍体 ($2n = 18$?) 已经绝灭, 或至少现在尚未发现。而且可以说, 该种(甚至该属)在四倍体和六倍体水平上基本上是稳定的, 在八倍体 ($2n = 64-70$) 和十倍体 ($2n = 88$) 水平上则表现不稳定, 并有染色体丢失现象。

在核型形态方面, 联邦德国的材料的核型 (Hong et al. 未发表) 为 $2n = 36 = 22m + 12sm + 2st(2SAT)$, 和我们这里报道的核型的差异在于, 在中国的材料中除 sat 染色体外, 还有两对 st 染色体 (臂比分别为 3.63 和 3.89), 而且 sat 染色体的短臂短得

表 3 舞鹤草的染色体参数

Table 3 The parameters of chromosomes in *Maianthemum bifolium* (L.) F. W. Schmidt

chr. No.	relative length (l. + s. = total)	arm ratio	chr. type
1	$5.5+4.6=10.1$	1.18	m
2	$5.0+3.3=8.3$	1.52	m
3	$5.6+2.1=7.7$	2.72	sm
4	$4.9+2.4=7.3$	2.09	sm
5	$4.1+2.9=7.0$	1.38	m
6	$4.8+2.0=6.8$	2.39	sm
7	$4.8+2.0=6.8$	2.47	sm
8	$4.5+1.3=5.8$	3.63	st
9	$4.2+1.1=5.3$	3.89	st
10	$3.1+1.3=4.4$	2.43	sm
11	$2.3+1.9=4.2$	1.20	m
12	$2.3+1.7=4.0$	1.38	m
13	$2.2+1.6=3.7$	1.4	m
14	$2.0+1.7=3.7$	1.19	m
15	$2.2+1.4=3.6$	1.64	m
16	$3.3+0.2+1.8=5.22$	1.73	t
17	$1.8+1.6=3.4$	1.15	m
18	$1.8+1.2=3.0$	1.56	m

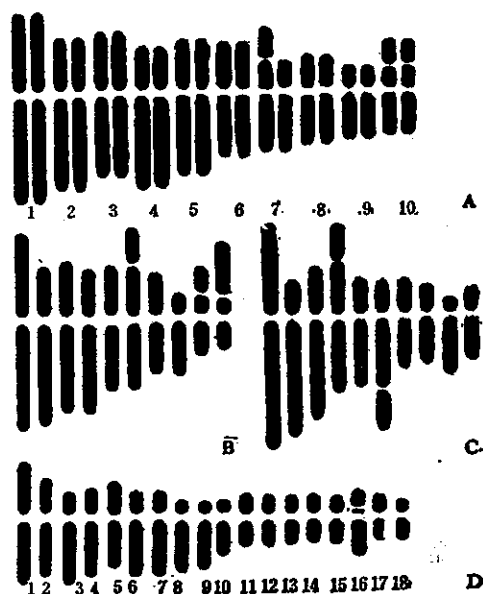


图3 A—B: 玉竹的核型模式图 A. 体细胞核型模式图 (PB85073), B. 单倍核型模式图 (PB85055); C. 小玉竹的单倍核型模式图 (PB85082), D. 舞鹤草的单倍核型模式图 (PB85057)。

Fig. 3. A—B. *Polygonatum odoratum*: A. Somatic idiogram (PB85073), B. Haploid idiogram (PB85055); C. Haploid idiogram of *Polygonatum humile* (PB85082); D. Haploid idiogram of *Maianthemum bifolium* (PB85057).

多, 臂比大于 10.0。显然中国材料的核型不对称性的程度较强。日本富士山 (Fuji) 的材料的核型为 $2n = 36 = 16m + 14sm + 4st + 2t(2SAT)$ (由 Kawano et al., 1967 的资料换算而得), 染色体长度范围为 $2.1-7.8\mu m$, 长度比值为 3.71。这一核型和中国的核型非常近似, 但比中国的核型更不对称, m 染色体更少, 长度比更大, 两条 st 染色体的臂比也更大, 均为 4.57。

(四) 黄精属 *Polygonatum* Mill.

1. 小玉竹 *Polygonatum humile* Fisch. ex Maxim. 材料取自河北赤城县大海陀山, 染色体数目为 $2n = 20$ (图版 1: G), 单倍核型模式图见图 3: C。核型公式 $2n = 20 = 10m(2SAT) + 6sm(2SAT) + 4st$, 染色体各参数见表 4。染色体大小为 $3.0-10.0\mu m$, 最长与最短染色体长度比值为 3.3。核型属 2B 型。

关于本种的染色体数目, 各地 (日本、朝鲜、苏联远东地区) 的材料都为 $2n = 20$ (Fedorov, 1969; Goldblatt, 1981, 1984, 1985), 仅仅在苏联远东托木斯克地区 $2n = 31$ 和 $2n = 20$ 同时存在。在中国, 汪劲武等 (1987) 报道北京东灵山的植物, Hong et al. (未发表) 发现吉林长白山的植物也都是 $2n = 20$ 。可见本种染色体数目恒定地具有 $2n = 20$, $2n = 31$ 是一个异常的、偶见的数目。

关于结构, 汪劲武等的报道是 $2n = 8m(2SAT) + 8sm + 4st$, 最长与最短染色体的长度比值为 3.0, 核型属 2B。长白山的植物为 $2n = 20 = 12m(4SAT) + 4sm + 4st$, 长度比值约为 3.0, 核型同样为 2B。可见核型有差异, 但不大, 3 个核型中均有 4 st , 主要差

表 4 黄精属两个种的染色体参数

Table 4 The parameters of chromosomes in two species of *Polygonatum* Mill.

taxon	chr. No.	relative length (l. + s. = total)	arm ratio	chr. type
<i>Polygonatum humile</i> Fisch. ex Maxim. (PB85082)	1	11.3+7.9=19.3	1.43	m
	2	10.3+2.9=13.2	3.50	st
	3	8.9+4.2=13.1	2.13	sm
	4	6.4+4.8=11.2	1.34	m
	5	5.9+3.1=9.0	1.94	sm
	6.1	6.1+2.8+3.5=12.4	2.16	sm
	7	4.4+2.8=7.2	1.55	m
	8	3.9+2.3=6.2	1.66	m
	9	4.9+1.2=6.1	4.15	st
	10	3.6+2.3=5.9	1.59	m
<i>Polygonatum odoratum</i> (Mill.) Druce (PB85073)	1	9.4+7.0=13.4	1.35	m
	2	8.3+4.9=13.2	1.71	sm
	3	7.1+5.2=12.3	1.37	m
	4	8.2+3.8=12.0	2.16	sm
	5	6.7+4.2=11.9	1.63	m
	6	5.5+4.1=9.6	1.34	m
	7	5.0+2.3+2.7=10.0 5.0+2.3=7.3	2.20	sm
	8	4.3+2.8=7.1	1.54	m
	9	4.0+1.9=5.9	2.13	sm
	10	3.6+1.7+2.1=7.4	2.07	sm
<i>Polygonatum odoratum</i> (PB85055)	1	9.5+7.5=17.0	1.27	m
	2	9.2+4.4=13.6	2.06	sm
	3	8.0+4.9=12.9	1.65	m
	4	8.1+4.2=12.3	1.92	sm
	5	6.1+4.4=10.5	1.40	m
	6	6.0+4.4+3.1=13.5	1.35	m
	7	4.6+3.8=8.4	1.21	m
	8	4.8+1.8=6.6	2.69	sm
	9	3.1+1.7+2.3=7.1	1.84	sm
	10	2.4+1.5+4.5=8.4	1.64	m

异在于 m 与 sm 染色体的比例及随体的数目和位置上。

2. 玉竹 *Polygonatum odoratum* (Mill.) Druce

本文报道两个居群。取自河北赤城县大海陀山的居群的染色体数目为 $2n = 20$ (图版 1: F)。体细胞核型模式图见图 3: A。核型公式为 $2n = 20 = 10m + 10sm(3SAT)$ 。染色体参数见表 4。染色体长度范围为 $3.1-8.8\mu m$, 最长与最短染色体的长度比值为 2.8。核型属 2B 型。来自陕西太白山的材料的染色体数目亦为 $2n = 20$ (图版 1: E), 单倍体核型模式图见图 3: B。核型公式为 $2n = 20 = 12m(4SAT) + 8sm(2SAT)$ 。染色体各参数见表 4。染色体大小为 $4.2-10.9\mu m$, 最长与最短染色体长度之比值为 2.6。核型属 2B。

因为这个种广泛分布欧亚大陆温带地区 (在我国南至台湾、江西和湖南), 而且常见,

对它的染色体报道很多。在中国以外从欧洲最西端的葡萄牙至亚洲最东部的日本,染色体数目一致,均为 $2n = 20$ (Fedorov, 1969; Moore, 1977; Goldblatt, 1981, 1984, 1985), 仅在东西伯利亚,靠近中国的萨彦岭东部发现有 $2n = 30$ 的个体 (Fregulevich, 1978)。但是在中国,则数目有变化。除了本文报道两个地点的材料为 $2n = 20$ 外,吉林长白山 (Fang, 1989)、河北青龙 (汪劲武等 1987)、四川金佛山 (栽培) 的材料也为 $2n = 20$ 。但来自北京金山 (李懋学等, 1980)、武汉、江苏宜兴和四川峨眉山 (Fang, 1989) 的植物则为 $2n = 22$, 而江苏宜兴的另一号材料和安徽大别山 (Fang, 1988) 的植物则为 $2n = 18$ 。由此可见, *Polygonatum odoratum* 仅在其分布区的南部 (北京、安徽、江苏、湖北和四川) 呈现了染色体数目的变异。

关于核型形态,对于 $2n = 20$ 的类型来说,奥地利的核型为 $2n = 12m(4SAT) + 8sm$, 属 2B 型 (Hong et al., 未发表); 吉林长白山的为 $2n = 14m + 6sm$, 比值为 2.53, 2B 型; 河北青龙的为 $2n = 12m + 8sm$, 比值为 2.07, 2B 型。这 3 个核型与我们本文报道的两个核型,除了随体 (或是否有次缢痕) 的差异外,区别虽然颇大,但是有各种过渡类型。但陈少风报道的核型为 $2n = 20 = 10m + 6sm + 4st$ 则显示了明显差异。对于 $2n = 18$ 的类型来说,安徽大别山的核型为 $2n = 10m + 8sm$, 比值为 3.14, 2B 型; 江苏宜兴的为 $2n = 8m + 10sm$, 比值为 2.63, 2B 型。其间的差异并不显著。对于 $2n = 22$ 的类型,江苏宜兴的核型为 $2n = 22 = 10m + 8sm + 4st$, 比值为 3.0, 2B 型; 武汉的为 $2n = 22 = 10m + 8sm + 4st$, 比值为 2.18, 2B 型; 四川峨眉山的为 $2n = 22 = 10m + 8sm + 4st$, 比值为 3.5, 2B 型。这三者虽然彼此差异显著,但也有过渡。值得注意的是,在北京以南地区,染色体数目有 $2n = 20$, $2n = 18$ 和 $2n = 22$ 三种,而且 $2n = 22$ 的核型不仅在数目上,而且在结构上与前两种核型有显著差异。在 $2n = 22$ 的核型中都有 4 条 st 染色体。除了陈少风报道的 $2n = 20$ 的核型中有 4 条 st 外,在其余所有的 $2n = 18$ 和 $2n = 20$ 的核型中均不存在。

最近,汪劲武等 (1988) 已经根据染色体数目和形态细微性状之间的相关性,把这一复合体重新划分为 3 个种,即 *P. odoratum*, *P. macropodium* Turcz. *P. simizui* Kitag.。但是,在这一类群染色体的变异范围内 (包括结构、随体或次缢痕的稳定性和变异范围),染色体数目与结构之间的关系,各染色体数目之间的进化关系,繁殖方式 (无性繁殖的程度) 与核型变异之间的关系等物种生物学问题仍然是值得研究的课题。

附录 (Appendix I): 材料来源 (The origin of the materials)

1. *Disporum megalanthum* Wang et Tang The Wolong Nature Reserve, Sichuan. N. slope in secondary young forest. 1940 m. 1985, 05, 07. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB 85016.
2. *D. megalanthum* Wang et Tang. Near Shangbaiyun, Mt. Taibai, the Qinling Range, Shaanxi. N. slope, in forest. 1750 m. 1985, 05, 24. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB85060.
3. *Disporopsis pernyi* (Hua) Diels. Near the village, Dazhubao Township, Mabian County, Sichuan. In bamboo forest. 800 m. 1984, 12, 05. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB84044.
4. *D. aspera* (Hua) Engl. ex Krause. Niuxinbao, Dazhubao Township, Mabian County, Sichuan. In valley forest. 1300 m. 1984, 12, 05. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB84047.
5. ———. Mt. Guangdou, Dazhubao Township, Mabian County, Sichuan. In secondary forest. 1400 m. 1984, 12, 03. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB84020.

6. *Maianthemum bifolium* (L.) F. W. Schmidt. Near Shangbaiyun, Mt. Taibai, the Qinling Range, Shaanxi. In secondary forest of N. slope. 1500 m. 1985, 05, 23. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB85057.
7. *Polygonatum humile* Fisch. ex Maxim. Mt. Dahaituo, Chicheng County, Hebei. Among rocks of dry stream bed. 1500 m. 1985, 06, 07. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB85082.
8. *P. odoratum* (Mill.) Druce. Near the Haoping Temple, Mt. Taibai, the Qinling Range, Shaanxi. In secondary forest of N. slope. 1350 m. 1985, 05, 23. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB85055.
9. ———. Mt. Dahaituo, Chicheng County, Hebei. N. slope, in sparse valley forest. 1490 m. 1985, 06, 06. Hong De-yuan & Zhu Xian-yun (洪德元和朱相云) PB85073.

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图版 1 说明 Explanation of Plate 1

根尖有丝分裂照片。

Micrographs of root-tip mitosis.

A—B, *Disporum megalanthum*: A, PB85016($\times 1020$); B, PB85060 ($\times 1020$); C, *Disporopsis pernyi*, PB84044 ($\times 1020$); D, *Disporopsis aspera*, 84047 ($\times 1020$). E—F, *Polygonatum odoratum*: E, PB85073 ($\times 1020$); F, PB85055($\times 1020$); G, *Polygonatum humile*, PB85082 ($\times 1420$); H, *Maianthemum bifolium*, PB85057 ($\times 1020$)

